



U.S. NUCLEAR REGULATORY COMMISSION
STANDARD REVIEW PLAN
OFFICE OF NUCLEAR REACTOR REGULATION

3.8.1 CONCRETE CONTAINMENT

REVIEW RESPONSIBILITIES

Primary - Structural Engineering Branch (SEB)

Secondary - None

I. AREAS OF REVIEW

The following areas relating to concrete containments or to concrete portions of steel/concrete containments, as applicable, are reviewed.

1. Description of the Containment

The descriptive information, including plans and sections of the structure, is reviewed to establish that sufficient information is provided to define the primary structural aspects and elements relied upon to perform the containment function. In particular, the type of concrete containment is identified and its structural and functional characteristics are examined. Among the various types of concrete containments reviewed are:

- a. Reinforced and prestressed concrete BWR containments utilizing the pressure-suppression concept, including the Mark I (modified lightbulb/torus), the Mark II (over/under), and the Mark III (with horizontal venting between a centrally located cylindrical drywell and a surrounding suppression pool).
- b. Reinforced concrete PWR containments utilizing the pressure-suppression concept with ice-condenser elements.
- c. Reinforced concrete PWR containments designed to function under sub-atmospheric conditions.
- d. Reinforced and prestressed concrete PWR dry containments designed to function at atmospheric conditions.

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USNRC STANDARD REVIEW PLAN

Standard review plans are prepared for the guidance of the Office of Nuclear Reactor Regulation staff responsible for the review of applications to construct and operate nuclear power plants. These documents are made available to the public as part of the Commission's policy to inform the nuclear industry and the general public of regulatory procedures and policies. Standard review plans are not substitutes for regulatory guides or the Commission's regulations and compliance with them is not required. The standard review plan sections are keyed to the Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants. Not all sections of the Standard Format have a corresponding review plan.

Published standard review plans will be revised periodically, as appropriate, to accommodate comments and to reflect new information and experience.

Comments and suggestions for improvement will be considered and should be sent to the U.S. Nuclear Regulatory Commission, Office of Nuclear Reactor Regulation, Washington, D.C. 20555.

- e. Reinforced and prestressed concrete PWR or BWR containments utilizing special features or modifications of the above-listed types.

Various geometries have been utilized for these containments. The geometry most commonly encountered is an upright cylinder topped with a dome and supported on a flat concrete base mat. Although applicable to any geometry, the specific provisions of this SRP section are best suited to the cylindrical type containment topped by a dome. If containments with other types of geometry are reviewed, the necessary modifications to this SRP section are made on a case-by-case basis.

The geometry of the containment is reviewed, including sketches showing plan views at various elevations and sections in at least two orthogonal directions. The arrangement of the containment and the relationship and interaction of the shell with its surrounding structures and with its interior compartment walls and floors are reviewed to determine the effect which these structures could have upon the design boundary conditions and expected structural behavior of the containment when subjected to design loads.

General information related to the containment shell is reviewed including the following:

- a. The base foundation slab, including the main reinforcement; the floor liner plate and its anchorage and stiffening system; the methods by which the interior structures are anchored through the liner plate and into the slab, if applicable.
- b. The cylindrical wall, including the main reinforcement and prestressing tendons, if any; the wall liner plate and its anchorage and stiffening system; the major penetrations and the reinforcement surrounding them including the personnel and equipment hatches and major pipe penetrations; major structural attachments to the wall which penetrate the liner plate such as beam seats, pipe restraints and crane brackets; and external supports, if any, attached to the wall to support external structures such as enclosure buildings.
- c. The dome and the ring girder, if any, including the main reinforcement and prestressing tendons; the liner plate and its anchorage and stiffening systems; and any major attachments to the liner plate made from the inside.
- d. Steel components of concrete containments that resist pressure and are not backed by structural concrete are covered by Standard Review Plan Section 3.8.2.

2. Applicable Codes, Standards, and Specifications

Information pertaining to design codes, standards, specifications, regulations, and regulatory guides, and other industry standards that are applied in the design fabrication, construction, testing, and inservice surveillance of the containment, is reviewed. The specific editions, dates, or addenda identified for each document are reviewed.

3. Loads and Loading Combinations

Information pertaining to the applicable design loads and various combinations thereof is reviewed with emphasis on the extent of compliance with Article CC-3000 of the ASME Section III, Division 2, "Code for Concrete Reactor Vessels and Containments" (Ref. 1) (hereafter "the Code"). The loads normally applicable to concrete containments include the following:

- a. Those loads encountered during preoperational testing.
- b. Those loads encountered during normal plant startup, operation, and shutdown, including dead loads, live loads, thermal loads due to operating temperature, and hydrostatic loads and hydrodynamic loads resulting from safety relief valve (SRV) actuation such as those present in pressure-suppression containments utilizing water.
- c. Those loads to be sustained during severe environmental conditions, including those induced by the design wind and the operating basis earthquake specified for the plant site.
- d. Those loads to be sustained during extreme environmental conditions, including those induced by the design basis tornado and the safe shutdown earthquake specified for the plant site.
- e. Those loads to be sustained during abnormal plant conditions, which include loss-of-coolant accidents (LOCA). The main abnormal plant condition for containment design is the design basis LOCA. Also considered are other accidents involving various high-energy pipe ruptures. Loads induced on the containment by such accidents include elevated temperatures and pressures and possible localized loads such as jet impingement and associated missile impact. For BWR containments the LOCA-related or LOCA/SRV-related hydrodynamic loads in suppression pools manifested as jet loads and/or pressure loads should be considered.
- f. Those loads to be sustained, if applicable, after abnormal plant conditions including flooding of the containment subsequent to a LOCA for fuel recovery.

The various combinations of the above loads that are normally postulated and reviewed include the following:

Testing loads; normal operating loads; normal operating loads with severe environmental loads; normal operating loads with extreme environmental loads; normal operating loads with abnormal loads; normal operating loads with severe environmental and abnormal loads; normal operating loads with extreme environmental and abnormal loads; and post-LOCA flooding loads with severe environmental loads, if applicable.

The loads and load combinations described above are generally applicable to all containments. However, other site-related design loads might be applicable also. Such loads, which are not normally combined with abnormal loads, are reviewed on a case-by-case basis. They include those loads induced by floods, potential aircraft crashes, explosive hazards in proximity of the site and projectiles and missiles generated from activities of nearby military installations.

4. Design and Analysis Procedures

The design and analysis procedures utilized for the containment are reviewed with emphasis on the extent of compliance with Article CC-3000 of the Code, particularly with respect to the following:

- a. Assumptions on boundary conditions.
- b. Treatment of axisymmetric and nonaxisymmetric loads.
- c. Treatment of transient and localized loads.
- d. Treatment of the effects of creep, shrinkage, and cracking of the concrete.
- e. A description of the computer programs utilized in the design and analyses.
- f. The treatment of the effects of seismically induced tangential (membrane) shears.
- g. The evaluation of the effects of variations in specified physical properties of materials on analytical results.
- h. The treatment of the large, thickened penetration regions.
- i. The treatment of the steel liner plate and its anchors. Steel penetration closures are covered by Standard Review Plan Section 3.8.2.
- j. Ultimate capacity of the concrete containment.
- k. Structural audit.
- l. Design report submitted for review.

5. Structural Acceptance Criteria

The design limits imposed on the various parameters that serve to quantify the structural behavior of the containment are reviewed, with emphasis on the extent of compliance with Article CC-3000 of the Code, specifically with respect to allowable stresses, strains, gross deformations and other parameters that identify quantitatively the margins of safety. For each load combination specified, the proposed allowable limits are compared with the acceptable limits delineated in Subsection II.5 of this SRP section. Included in these allowable limits are the following major parameters:

- a. Compressive stresses in concrete, including membrane, membrane plus bending and localized stresses.
- b. Shear stresses in concrete, particularly those tangential (membrane) stresses induced by lateral loads.
- c. Tensile stresses in reinforcement.

- d. Tensile stresses in prestressing tendons.
- e. Tensile or compressive strain limits in the liner plate, including membrane and membrane plus bending.
- f. Force/displacement limits in the liner plate anchors, including those induced by strains in the adjacent concrete.

6. Materials, Quality Control, and Special Construction Techniques

Information provided on materials that are used in construction of the containment is reviewed with emphasis on the extent of compliance with Article CC-2000 of the Code. Among the major materials of construction that are reviewed are the following:

- a. The concrete ingredients.
- b. The reinforcing bars and splices.
- c. The prestressing system.
- d. The liner plate.
- e. The liner plate anchors and associated hardware.
- f. The structural steel used for embedments such as beam seats and crane brackets.
- g. The corrosion-retarding compounds used for the prestressing tendons.

The quality control program that is proposed for the fabrication and construction of the containment is reviewed with emphasis on the extent of compliance with Articles CC-4000 and CC-5000 of the Code, including the following:

Examination of the materials including tests to determine the physical properties of concrete, reinforcing steel, mechanical splices, the liner plate and its anchors, and the prestressing system, if any; placement of concrete; and erection tolerances of the liner plate, reinforcement and prestressing system.

Special, new or unique construction techniques, if proposed, such as slip forming are reviewed on a case-by-case basis to determine their effects on the structural integrity of the completed containment.

7. Testing and Inservice Surveillance Requirements

The preoperational structural testing program for the completed containment and for individual components, such as personnel and equipment locks and hatches, is reviewed including the objectives of the test program and acceptance criteria, with emphasis on the extent of compliance with Article CC-3000 of the Code. Inservice surveillance programs such as the periodic surveillance and inspection of the prestressing tendons, if any, are also reviewed, including the applicable Technical Specifications, at the operating license stage. Special testing and inservice surveillance requirements proposed for new or previously untried design approaches are also reviewed on a case-by-case basis.

SEB coordinates other branches evaluations that interface with structural engineering aspects of the review as follows: Determination of structures which are subject to quality assurance program in accordance with the requirements of Appendix B to 10 CFR Part 50 is performed by the Mechanical Engineering Branch (MEB) as part of its primary review responsibility for SRP Sections 3.2.1 and 3.2.2. SEB will perform its review of safety-related structures on that basis. Determination of pressure loads from high energy lines located in safety-related structures other than containment is performed by the Auxiliary Systems Branch (ASB) as part of its primary review responsibility as described for SRP Section 3.1.6.1. SEB accepts the loads thus generated as approved by the ASB, to be included in the load combination equations of this SRP section. Determination of loads generated due to pressure under accident conditions is performed by the Containment Systems Branch (CSB) as part of its primary review responsibility for SRP Section 6.2.1. SEB accepts the loads thus generated, as approved by the (CSB), to be included in the load combinations in this SRP section. The review for Quality Assurance is coordinated and performed by the Quality Assurance Branch as part of its primary review responsibility for SRP Section 17.0.

For those areas of review identified above as being reviewed as part of the primary review responsibility of other branches, the acceptance criteria necessary for the review and their methods of application are contained in the referenced SRP section of the corresponding primary branch.

II. ACCEPTANCE CRITERIA

SEB acceptance criteria for the design of the concrete containment is based on meeting the relevant requirements of the following regulations:

1. 10 CFR Part 50.55a and General Design Criterion 1 as they relate to concrete containment being designed, fabricated, erected, and tested to quality standards commensurate with the importance of the safety function to be performed.
2. General Design Criterion 2 as it relates to the design of the concrete containment being capable to withstand the most severe natural phenomena such as winds, tornadoes, floods, and earthquakes and the appropriate combination of all loads.
3. General Design Criterion 4 as it relates to the concrete containment being capable of withstanding the dynamic effects of equipment failures including missiles and blowdown loads associated with the loss-of-coolant accident.
4. General Design Criterion 16 as it relates to the capability of the concrete containment to act as a leaktight membrane to prevent the uncontrolled release of radioactive effluents to the environment.
5. General Design Criterion 50 as it relates to containment internal structures being designed with sufficient margin of safety to accommodate appropriate design loads.

The Regulatory Guides and industry standards identified in item 2 of this subsection provides information, recommendations and guidance and, in general, decides a basis acceptable to the staff that may be used to implement the requirements of 10 CFR Part 50, 50.55a, and GDC 1, 2, 4, 16; and 50. Also,

specific acceptance criteria necessary to meet these relevant requirements of these regulations for the areas of review, described in subsection I of this SRP section are as follows:

1. Description of the Containment

The descriptive information in the safety analysis report (SAR) is considered acceptable if it meets the minimum requirements set forth in Section 3.8.1.1 of the "Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants" (Ref. 2). If the concrete containment has new or unique features that are not specifically covered in the "Standard Format...", the reviewer determines that the information necessary to accomplish a meaningful review of the structural aspects of these new or unique features is presented, as appropriate.

2. Applicable Codes, Standards, and Specifications

The design, materials, fabrication, erection, inspection, testing, and inservice surveillance of concrete containments are covered by codes, standards, specifications, and guides that are either applicable in their entirety or in part. The following codes and guides are acceptable.

<u>Code</u>	<u>Title</u>
ASME Section III Division 2	Code for Concrete Reactor Vessels and Containments
<u>Regulatory Guides</u>	<u>Title</u>
1.10	Mechanical (Cadmold) Splices for Reinforcing Bars of Category I Concrete Structures
1.15	Testing of Reinforcing Bars for Category I Concrete Structures
1.18	Structural Acceptance Testing for Concrete Primary Reactor Containments
1.19	Nondestructive Examination of Primary Containment Liner Welds
1.35	Inservice Surveillance of Ungrouted Tendons in Prestressed Concrete Containment Structures
1.55	Concrete Placement in Category I Structures
1.90	Inservice Surveillance in Prestressed Concrete Containments with Grouted Tendons
1.94	Quality Assurance Requirements for Installation, Inspection and Testing of Structural Concrete and Structural Steel during the Construction Phase of Nuclear Power Plants

- 1.103 Post-Tensioned Prestressing System for Concrete Reactor Vessels and Containments
- 1.107 Qualification for Cement Grouting for Prestressing Tendons in Containment Structures
- 1.136 Material for Concrete Containments

3. Loads and Loading Combinations

The specified loads and load combinations are acceptable if found to be in accordance with Article CC-3000 of the Code with the exceptions listed below taken to the requirements specified in Table CC-3230-1.

- a. In the third combination under "abnormal/severe environmental condition "0.5" under Ess should be replaced by the word "or."
- b. The maximum values of P_a , T_a , R_a , Y_r , Y_j and Y_m should be applied simultaneously, where appropriate, unless a time-history analysis is performed to justify doing otherwise.
- c. Hydrodynamic loads resulting from LOCA and/or SRV actuation should be combined as indicated in the appendix to this SRP Section.
- d. Where post-LOCA flooding is a design consideration, the following combination should also be considered in the factored load category:
 $1.0 D + 1.0 L + 1.0 F + 1.0 F_{eqo}$; where D, L, F_{eqo} are as defined in the Code and F is the load generated by the post-LOCA flooding of the containment.

4. Design and Analysis Procedures

The procedures of design and analysis utilized for the concrete containment, including the steel liner, are acceptable if found in accordance with those stipulated in Article CC-3300 of the Code. In particular, for the areas of review outlined in Subsection I.4 of this SRP section, the following procedures are, in general, acceptable:

a. Assumptions on boundary conditions

The boundary conditions depend on the methods of analysis to be used and the portions of the containment shell to be separately analyzed. If the analysis is to be accomplished through the use of the finite element technique, and is to include the foundation media, the boundary would be the demarcation lines separating the foundation mass taken into consideration in the analysis from the surrounding media. The boundaries of the foundation mass considered have to be so selected that any further extension of the boundaries will not affect the results by more than 15 percent.

If only the containment shell and its foundation mat are taken into consideration in the analysis, then the bottom of the foundation slab is the boundary of the analytical model. The foundation media should be represented by appropriate soil springs.

If separate analyses of the containment shell and the base mat are to be used, it is considered acceptable if strain comparability of the bottom portion of the shell with the base mat is maintained.

b. Axisymmetric and nonaxisymmetric loads

Even with the large penetrations and buttresses that may be utilized in the shell, the overall behavior of the shell has been shown to be axisymmetric under pressure. Therefore, it is acceptable if such an assumption is made with respect to the containment geometry. However, for loads such as those induced by wind, tornados, earthquakes, and pipe rupture, the nonaxisymmetric effect of these loads should be considered.

c. Transient and localized loads

During normal operation, a linear temperature gradient across the containment wall thickness may develop. After the loss-of-coolant accident (LOCA), however, the sudden increase in temperature in the steel liner and the adjacent concrete may produce a nonlinear transient temperature gradient across the containment wall thickness. Effects of such transient loads should be considered.

In a PWR ice-condenser containment, nonaxisymmetric and transient pressure loads resulting from compartmentation inside the containment will develop after a LOCA. In a BWR pressure suppression containment nonaxisymmetric and transient pressure loads resulting from earthquakes, LOCA and/or SRV actuation including fluid-structure interaction should be considered.

For the effects of such localized and transient loads, the overall behavior of the containment structure should first be determined. A portion of the containment shell, within which the localized or transient load is located, should then be analyzed, using the results obtained from the analysis of the overall vessel behavior as boundary conditions.

d. Creep, shrinkage, and cracking of concrete

Creep and shrinkage values for concrete should be established by tests performed on the concrete which is to be used in the containment structure, or from data obtained on completed containments constructed of the same kind of concrete. In establishing these values, consideration should be given to the differences in the environment between the test samples and the actual concrete in the structure. Cracking of the concrete may be considered in either of the following two ways: (i) the moments, forces, and shears under load may be obtained on the basis of an uncracked section for all loading combinations. In sizing the reinforcing steel required, however, the concrete shall not be relied upon for resisting tension. Thermal moments may be modified to take creep and cracking into consideration. (ii) For axisymmetrical loadings, cracking of the concrete may be considered through the use of computer programs which are capable of treating such cracking by an iterative process. However, for nonaxisymmetric loadings, most of the computer programs available do not have the capability of considering cracking, since the structure itself

becomes nonaxisymmetric when concrete cracking is to be considered iteratively. Accordingly, if the concrete is cracked under any load combination involving axisymmetric and nonaxisymmetric loadings, a method should be described for considering cracking. Such methods are reviewed on a case-by-case basis.

e. Computer programs

The computer programs used in the design and analysis should be described and validated by any of the following procedures or criteria:

- (i) The computer program is a recognized program in the public domain and has had sufficient history of use to justify its applicability and validity without further demonstration.
- (ii) The computer program solution to a series of test problems has been demonstrated to be substantially identical to those obtained by a similar and independently written and recognized program in the public domain. The test problems should be demonstrated to be similar to or within the range of applicability of the problems analyzed by the public domain computer program.
- (iii) The computer program solution to a series of test problems has been demonstrated to be substantially identical to those obtained from classical solutions or from accepted experimental tests, or to analytical results published in technical literature. The test problems should be demonstrated to be similar to or within the range of applicability of the classical problems analyzed to justify acceptance of the program.

A summary comparison should be provided for the results obtained in the validation of each computer program.

f. Tangential shear

Design and analysis procedures for tangential shear are acceptable if in accordance with those contained in Article CC-3000 of the Code. The exceptions taken by the Regulatory staff to the provisions of this article, as contained in subsection II.5 of this SRP section, are to be noted.

g. Variation in physical material properties

For considering the effects of possible variations in the physical properties of materials on the analytical results, the upper and lower bounds of these properties should be used in the analysis, wherever critical. Among the physical properties that may be critical include the soil modulus, and modulus of elasticity and Poisson's ratio of concrete.

h. Thickened penetrations

The effect of the large, thickened penetration regions on the overall behavior of the containment may be treated in the same manner as for localized loads discussed in item (c).

i. Steel liner plate and anchors

For the design and analysis of the liner plate and its anchorage system, the procedures furnished are found adequate and acceptable if in accordance with the provisions of Subarticle CC-3600 of the Code. In general, the liner plate analysis should consider deviations in geometry due to fabrication and erection tolerances, and variations of the assumed physical properties of the liner and anchor material. Since the liner plate is usually anchored at relatively closely spaced intervals, the analysis procedures are acceptable if based on either the classical plate or beam theory. Since the concrete shell is much stiffer than the liner plate, the strains in the liner will essentially follow those in the concrete. The strains in the concrete under the various load combinations as obtainable from the analysis of the shell are thus imposed on the liner plate and the resulting strains and stresses in the liner and its anchors should be lower than the allowable limits defined in Tables CC-3720-1 and CC-3730-1 of the Code.

j. Ultimate capacity of concrete containment

An analysis should be performed to determine the ultimate capacity of the containment.

The pressure-retaining capacity of localized areas as well as of the overall containment structure should be determined.

The analysis should be made on the basis of the allowable material strength specified in the Code. However, if the actual material properties such as concrete cylinder compressive strength, mill test results of reinforcing steel and liner plate, strength variations indicated by mill test certificates and other uncertainties are available, the lower and upper bounds of the containment capacity may be established statistically.

The details of the analysis and the results should be submitted in a report form with the following identifiable information.

- (1) The original design pressure, P_a , as defined in the Code,
- (2) Calculated static pressure capacity,
- (3) Equivalent static pressure response calculated from dynamic pressure,
- (4) The associated failure mode,
- (5) The stress-strain relation of the liner steel and reinforcing and/or prestressing steel and the behavior of the liner under the postulated loading conditions in relation to that of the reinforcing and/or prestressing steel,
- (6) The criteria governing the original design and the criteria used to establish failure;

- (7) Analysis details and general results, and
- (8) Appropriate engineering drawings adequate to allow verification of modeling and evaluation of analyses employed for the containment structure.

k. Structural Audit

Structural audit is conducted as described in Appendix B to SRP Section 3.8.4.

l. Design Report

Design report is considered acceptable when it satisfies the guidelines of Appendix C to SRP Section 3.8.4.

5. Structural Acceptance Criteria

- a. For the structural portions of the containment, the specified allowable limits for stresses and strains are acceptable if they are in accordance with Subsection CC-3400 of the Code but with the following exceptions:

CC-3421.5

Under no conditions shall the tangential shear stress carried by the concrete, v_c , exceed 40 psi and 60 psi for the load combinations of Table CC-3230-1, representing abnormal/severe environmental and abnormal/ extreme environmental conditions, respectively.

For prestressed concrete, the principal tensile stress shall not exceed $4\sqrt{f'_c}$.

C-3431.1

The 33-1/3% increase in allowable stresses is permitted only for temperature loads and not for OBE or wind loads.

- b. For the liner plate and its anchorage system, the specified limits for stresses and strains are acceptable if in accordance with Tables CC-3720-1 and CC-3730-1 of the Code, respectively.

6. Materials, Quality Control, and Special Construction Techniques

- a. The specified materials of construction are acceptable if in accordance with Article CC-2000 of the Code augmented by Regulatory Guides 1.103, 1.107, and 1.136.
- b. Quality control programs are acceptable if in accordance with applicable portions of Articles CC-4000 and CC-5000 of the Code as augmented by Regulatory Guides 1.10 for Cadweld reinforcement splicing (Ref. 3), 1.15 for testing of reinforcing bars (Ref. 4), 1.19 for the nondestructive examination of the liner plate welds (Ref. 5), 1.55 for concrete placement (Ref. 6), and 1.94 for Quality Assurance requirements (Ref. 10).

- c. Special construction techniques, if any, are reviewed on a case-by-case basis.

7. Testing and Inservice Surveillance Requirements

- a. Procedures for the postconstruction preoperational structural proof test proposed for the containment are acceptable if found in accordance with those delineated in Article CC-6000 of the Code as augmented by the provisions delineated in Regulatory Guide 1.18 (Ref. 7).
- b. For prestressed concrete containments, inservice surveillance requirements for the tendons, as presented in the Technical Specifications of the Operating License, are acceptable if in accordance with Regulatory Guides 1.35 for ungrouted tendons (Ref. 8) and 1.90 for grouted tendons (Ref. 9), respectively.

III. REVIEW PROCEDURES

The reviewer selects and emphasizes material from the review procedures described below as may be appropriate for a particular case.

1. Description of the Containment

After the type of containment and its functional characteristics are identified, information on similar and previously licensed applications is obtained for reference. Such information, which is available in safety analysis reports and amendments of previous license applications, enables identification of differences for the case under review. These differences require additional scrutiny and evaluation. New and unique features that have not been used in the past are of particular interest and are examined in greater detail. The information furnished in the SAR is reviewed for completeness in accordance with the "Standard Format..." (Ref.2). A decision is then made with regard to the sufficiency of the descriptive information provided in the SAR. Any additional required information not provided is requested from the applicant at an early stage of the review process.

2. Applicable Codes, Standards, and Specifications

The list of codes, standards, guides, and specifications are checked against the list in subsection II.2 of this SRP section. The reviewer assures that the applicable edition and stated effective addenda are utilized.

3. Loads and Loading Combinations

The reviewer verifies that the loads and load combinations, as described by the applicant, are as conservative as those referenced in subsection II.3 of this SRP section. Loading conditions that are unique to the site, such as potential aircraft crashes, and that are not specifically covered in subsection II.3 are treated on a case-by-case basis. Any deviations from the acceptance criteria for loads and load combinations that have not been adequately justified are identified as unacceptable and this information is transmitted to the applicant for further consideration.

4. Design and Analysis Procedures

The reviewer assures himself that the applicant has committed to utilize design and analysis procedures delineated in Article CC-3000 of the Code. Any exceptions to these procedures are reviewed and evaluated on a case-by-case basis. In particular, the areas of review contained in subsection II.4 of this SRP section are evaluated for conformance with the acceptance criteria.

5. Structural Acceptance Criteria

The limits on allowable stresses and strains in the concrete, reinforcement, liner plate and its anchors, and in components of the prestressing system, if any, are reviewed and compared with the acceptable limits referenced in subsection II.5 of this SRP section. Where the applicant proposes to exceed some of these limits for some of the load combinations and at some localized points on the structure, the justification, provided to show that the structural integrity of the containment will not be affected, is reviewed. If such justification is unacceptable, the applicant is required to submit additional justification or otherwise comply with the acceptance criteria delineated in subsection II.5 of this SRP section.

6. Materials, Quality Control, and Special Construction Techniques

The information provided on materials, quality control programs, and special construction techniques, if any, is reviewed and compared with that referenced in subsection II.6 of this SRP section. If a material not used in previously licensed applications is utilized, the applicant is requested to provide sufficient test and user data to establish the acceptability of the material. Similarly, any new quality control programs or construction techniques are reviewed and evaluated to assure that there will be no degradation of structural quality that might affect the structural integrity of the containment, the liner plate, and its anchorage system.

7. Testing and Inservice Surveillance Requirements

The initial structural overpressure test program is reviewed and compared with that indicated as acceptable in subsection II.7 of this SRP section. Proposed deviations are considered on a case-by-case basis. Inservice surveillance programs, particularly for the prestressing tendons, if any, as presented in the Technical Specifications of the Operating License, are similarly reviewed.

IV. EVALUATION FINDINGS

The reviewer verifies that sufficient information has been provided to satisfy the requirements of this SRP section, and concludes that his evaluation is sufficiently complete and adequate to support the following type of conclusive statement to be included in the staff's Safety Evaluation Report:

The staff concludes that the design of the concrete containment is acceptable and meets the relevant requirements of 10 CFR Part 50, §50.55a, and General Design Criteria 1, 2, 4, 16, and 50. This conclusion is based on the following:

1. The applicant has met the requirements of Section 50.55a and GDC 1 with respect to assuring that the concrete containment is designed, fabricated, erected, contracted, tested and inspected

to quality standards commensurate with its safety function to be performed by meeting the guidelines of regulatory guides and industry standards indicated below.

2. The applicant has met the requirements of GDC 2 by designing the concrete containment to withstand the most severe earthquake that has been established for the site with sufficient margin and the combinations of the effects of normal and accident condition with the effects of environmental loadings such as earthquakes and other natural phenomena.
3. The applicant has met the requirements of GDC 4 by assuring that the design of the concrete containment is capable of withstanding the dynamic effects associated with missiles, pipe whipping, and discharging fluids.
4. The applicant has met the requirements of GDC 16 by designing the concrete containment so that it is an essentially leaktight barrier to prevent the uncontrolled release of radioactive effluents to the environment.
5. The applicant has met the requirements of GDC 50 by designing the concrete containment to accommodate, with sufficient margin, the design leakage rate, calculated pressure and temperature conditions resulting from accident conditions, and by assuring that the design conditions are not exceeded during the full course of the accident condition. In meeting these design requirements, the applicant has used the recommendations of Regulatory Guides and industry standards indicated below. The applicant has also performed appropriate analysis which demonstrates that the ultimate capacity of the containment will not be exceeded and establishes the minimum margin of safety for the design.

The criteria used in the analysis, design, and construction of the concrete containment structure to account for anticipated loadings and postulated conditions that may be imposed upon the structure during its service lifetime are in conformance with established criteria, and with codes, standards, guides, and specifications acceptable to the Regulatory staff. These include meeting the positions of Regulatory Guides 1.10, 1.15, 1.18, 1.19, 1.35, 1.55, 1.90, 1.94, 1.103, 1.107, 1.136 and industry standard ASME Boiler and Pressure Vessel Code, Section III, Division 2.

The use of these criteria as defined by applicable codes, standards, guides, and specifications; the loads and loading combinations; the design and analysis procedures; the structural acceptance criteria; the materials, quality control programs, and special construction techniques; and the testing and inservice surveillance requirements, provide reasonable assurance that, in the event of winds, tornadoes, earthquakes and various postulated accidents occurring within and outside the containment, the structure will withstand the specified design conditions without impairment of structural integrity or safety function of limiting the release of radioactive material.

V. IMPLEMENTATION

The following is intended to provide guidance to applicants and licensees regarding the NRC staff's plans for using this SRP section.

Except in those cases in which the applicant proposes an acceptable alternative method for complying with specified portions of the Commission's regulations, the method described herein will be used by the staff in its evaluation of conformance with Commission regulations.

Implementation schedules for conformance to parts of the method discussed herein are contained in the referenced regulatory guides.

VI. REFERENCES

1. ASME Boiler and Pressure Vessel Code, Section III, Division 2, "Code for Concrete Reactor Vessels and Containments."
2. Regulatory Guide 1.70, "Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants."
3. Regulatory Guide 1.10, "Mechanical (Cadmold) Splices in Reinforcing Bars of Category I Concrete Structures."
4. Regulatory Guide 1.15, "Testing of Reinforcing Bars for Category I Concrete Structures."
5. Regulatory Guide 1.19, "Nondestructive Examination of Primary Containment Liner Welds."
6. Regulatory Guide 1.55, "Concrete Placement in Category I Structures."
7. Regulatory Guide 1.18, "Structural Acceptance Test for Concrete Primary Reactor Containments."
8. Regulatory Guide 1.35, "Inservice Surveillance of Ungouted Tendons in Prestressed Concrete Containments."
9. Regulatory Guide 1.90, "Inservice Surveillance in Prestressed Concrete Containments with Gouted Tendons."
10. Regulatory Guide 1.94, "Quality Assurance Requirements for Installation, Inspection, and Testing of Structural Concrete and Structural Steel During the Construction Phase of Nuclear Power Plants."
11. Regulatory Guide 1.103, "Post-Tensional Prestressing Systems for Concrete Reactor Vessels and Containments."
12. Regulatory Guide 1.107, "Qualifications for Cement Grouting for Prestressing Tendons in Containment Structures."
13. Regulatory Guide 1.136, "Materials, Construction, and Testing of Concrete Containments."
14. 10 CFR Part 50, Appendix A, General Design Criterion 1, "Quality Standard and Records."

15. 10 CFR Part 50, Appendix A, General Design Criterion 2, "Design Bases for Protection Against Natural Phenomena."
16. 10 CFR Part 50, Appendix A, General Design Criterion 4, "Environmental and Missile Design Bases."
17. 10 CFR Part 50, Appendix A, General Design Criterion 16, "Containment Design."
18. 10 CFR Part 50, Appendix A, General Design Criterion 50, "Containment Design Basis."
19. 10 CFR Part 50, §50.55a, "Codes and Standards."

Appendix to SRP Section 3.8.1

STRUCTURAL ENGINEERING BRANCH POSITION
U.S. NUCLEAR REGULATORY COMMISSION

BWR MARK III CONTAINMENT POOL DYNAMICS

1. POOL SWELL

- a. Bubble pressure, bulk swell and froth swell loads, drag pressure and other pool swell loads should be treated as abnormal pressure loads, P_a . Appropriate load combinations and load factors should be applied accordingly.
- b. The pool swell loads and accident pressure may be combined in accordance with their actual time-dependent mutual occurrence.

2. SAFETY RELIEF VALVE (SRV) DISCHARGE

- a. The SRV loads should be treated as live loads in all load combinations with the exception of the combination that contains $1.5 P_a$ where a load factor of 1.25 should be applied to the appropriate SRV loads.
- b. A single active failure causing one SRV discharge must be considered in combination with the design basis accident (DBA).
- c. Appropriate multiple SRV discharge should be considered in combination with the small-break accident (SBA) and intermediate break accident (IBA).
- d. Thermal loads due to SRV discharge should be treated as T_o for normal operation and T_a for accident conditions.